RACIAL COMPOSITION OF MIGRANT POPULATIONS OF SANDHILL CRANES IN THE NORTHERN PLAINS STATES

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During recent years, there has been increasing pressure to expand hunting seasons on Sandhill Cranes (*Grus canadensis*) in the northern plains states. Hunters desire to take advantage of the opportunity presented by the sizable flocks of this large bird in this area. Prior to passage of the Migratory Bird Treaty Act in 1918, the Sandhill Crane was hunted and considered to have high sporting and eating qualities. In addition, complaints have been received from farmers regarding grain crop depredations by cranes. It has been suggested (Boeker et al., 1961:16) that flocks of cranes would be more widely dispersed by hunting pressure, thus alleviating local damage to crops.

The fact that three apparent subspecies of the Sandhill Crane occur in the northern plains of the United States during migration (Walkinshaw, 1965) complicates the situation since one of these, the Greater Sandhill Crane (*Grus canadensis tabida*) was until late 1971 officially designated as rare by the U.S. Bureau of Sport Fisheries and Wildlife (Anon., 1968). The other subspecies occurring in this area are the Lesser Sandhill Crane (*Grus c. canadensis*) and the Canadian Sandhill Crane (*Grus c. rowani*). We are using these subspecific designations on a tentative basis only. The validity of the *rowani* subspecies has been questioned (e.g. Stephen, 1967), and more detailed work on the breeding grounds in the future may demonstrate the existence of gradient populations of Sandhill Cranes that occur between areas occupied by typical members of the three currently recognized subspecies. These populations may be expected to differ in migrational and wintering patterns as well as in morphological characteristics. Such clines have been demonstrated for the Canada Goose (*Branta canadensis*) (Aldrich, 1946; Hanson, 1965:13), but evidence accumulated from cranes on their breeding grounds is insufficient to establish a similar pattern in this species.

Until adequate breeding-ground studies have been conducted, it is useful for the purposes of this paper to assume the existence of three populations which may be distinguished on the basis of the average size of the cranes which comprise each population. For reasons of convenience, at least, these populations can be referred to as *canadensis*, *rowani*, and *tabida*.

Current information concerning the breeding ranges of the three northern subspecies was derived from reports by Walkinshaw (1949, 1965), supplemented with data furnished by John W. Aldrich (pers. comm.). The Lesser Sandhill Crane, the most northern of the subspecies, breeds on the Arctic

tundra of northwestern Canada, Alaska, and northeastern Siberia. Breeding populations of the Canadian Sandhill Crane favor the boreal forest and aspen parklands of west-central Canada. The breeding range of the eastern population of the Greater Sandhill Crane formerly extended throughout the glaciated prairie region in south-central Canada and north-central United States, and also included disjunct outliers of prairie or prairie-forest ecotonal communities within the Lake Forest (hardwood-pine) region to the east. At present, this population appears to be restricted to isolated groups of breeding birds in Michigan, Wisconsin, and northern Minnesota, and to groups of birds that are probably breeding in southwestern Ontario and southeastern Manitoba. Another segment of the breeding population of the Greater Sandhill Crane occurs west of the continental divide in southern British Columbia and in several western states, and therefore is not considered in this discussion.

Numerous migrating Sandhill Cranes (often many thousands) occur regularly in a few local staging areas. In North Dakota these concentrations are normally found from late August to early November on glacial outwash plains in the vicinity of wetland complexes composed of large shallow lakes that are brackish, subsaline, or saline. These include semipermanent lakes, permanent lakes, and alkali lakes (wetland habitat types IV-D, IV-E, V-E, and VI—Stewart and Kantrud, 1971). Fen pockets or man-made dugouts that occur along the margins of these lakes are utilized as roosting sites. Scattered flocks of cranes range out for several miles from these roosting sites to forage on croplands (Madsen, 1967). Similar habitat complexes are occupied in Montana but only for brief periods from late September through early November. In northwestern Minnesota roosting concentrations occur for a brief period during the latter half of September (Robert E. Farmes, pers. comm.) on large fens or alkaline bogs within the prairie-forest ecotone.

The primary purpose of this study was to determine the racial composition of Sandhill Crane populations that occur in northwestern Minnesota, North Dakota, and eastern Montana during the fall migration period. These investigations were initiated in 1970 and continued in 1971. Particular attention was given to the geographical distribution and seasonal occurrence of these populations as related to racial composition. Incidental information concerning the morphological distinctiveness of the three northern populations of Sandhill Cranes was also obtained.

METHODS

During the fall migration periods in 1970 and 1971, 180 Sandhill Cranes (153 adult and 27 immature) were collected in five major concentration areas (Fig. 1) of the northern plains states. These collections involved 11 series of specimens that were taken during early and/or late portions of the fall migration period. Attempts were made to collect the adult specimens in a random manner, whereas concurrent collections of immature

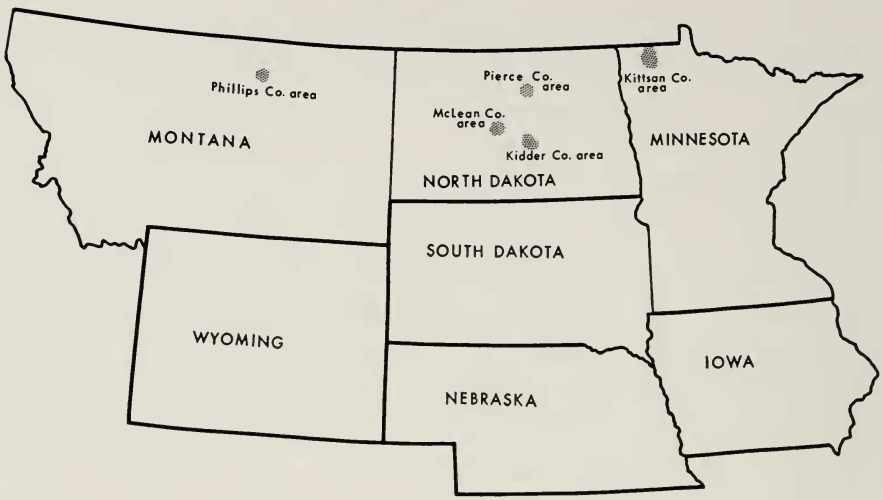

FIG. 1. Collection sites of migrant Sandhill Cranes.

birds were largely incidental. The age and sex composition of birds comprising each series of specimens and the dates of collection are indicated in Table 1.

All of the collected specimens were weighed in the field, and detailed laboratory examinations were made at the Northern Prairie Wildlife Research Center. These examinations involved sex and age determinations and the following linear measurements: wing chord, tarsus length, exposed culmen, culmen post nares (culmen from posterior edge of nostril), middle toe (without claw), and tail length.

A wing, a leg, and the head of each specimen collected in 1970, together with information on sex and age, were sent to Dr. John W. Aldrich, Division of Wildlife Research, U.S. Bureau of Sport Fisheries and Wildlife, Washington, D.C. He made independent measurements and, using those of wing chord, tarsus length, and culmen post nares, determined subspecies from them. This afforded a valuable opportunity for comparison and confirmation of our results.

MEASUREMENTS OF BREEDING SPECIMENS

The identification of the subspecies represented by an individual specimen collected during the migration period is preferably determined by comparing it with adequate series of breeding specimens that are typical of each of the relevant subspecies. Unfortunately, only minimal requirements are satisfied in this respect by the limited series of breeding Sandhill Crane specimens that are available. Walkinshaw (pers. comm.) has compiled a useful list of measurements together with data on collection dates and locations. Of these specimens and those described by Lumsden (1971), we selected individuals collected between late April and mid-July to form a sample of breeding ground specimens of known subspecies. In our analysis

Table 1
Collections of Migrant Sandhill Cranes

	Adults		Immatures	
	Male	Female	Male	Female
Kittson Co., Minnesota				
22–24 September 1970	14	6	3	4
Pierce Co., North Dakota				
14 September 1971	7	5	0	1
27–28 October 1971	4	4	0	0
Kidder Co., North Dakota				
8–15 September 1970	11	14	2	1
26 October–1 November 1970	14	7	2	4
3–4 September 1971	9	6	0	0
McLean Co., North Dakota				
28 October–3 November 1970	18	9	2	2
7 September 1971	3	2	0	1
27–28 September 1971	6	2	1	0
Phillips Co., Montana				
4 October 1970	2	2	1	1
3 October 1971	5	3	1	1
Total	93	60	12	15

of the birds, we employed all available complete measurements of wing chord, tarsus length, and exposed culmen taken from adults of known sex. These measurements are summarized in Table 2.

In order to appraise the separability of the intermediate population, *rowani*, a series of statistical tests can be formulated, following Rao (1962, 1965: 490–493). Omit the presumed *rowani* specimens and assume for the moment that only two populations, *canadensis* and *tabida*, are separable. Let $\mu = (\mu_1, \mu_2, \mu_3)$ represent the vector of means of wing chord, tarsus length, and exposed culmen. Then μ_c is the mean vector for *canadensis*, and μ_t is the mean vector for *tabida*. Assume both populations have a common variance-covariance matrix, and let S be an estimate of it, based on n degrees of freedom. Then let $X = (X_1, X_2, X_3)$ be an observation of wing chord, tarsus length, and exposed culmen of any crane to be examined. The first test is whether or not X could reasonably have come from either a *canadensis* or *tabida* population or from a population intermediate to them. The form of this test is

$$F_0 = (n-1)\{(X-\mu_t)'S^{-1}(X-\mu_t) - [(\mu_c-\mu_t)'S^{-1}(X-\mu_t)]^2/(\mu_c-\mu_t)'S^{-1}(\mu_c-\mu_t)\}/2n$$

which is distributed as an F ratio with 2 and $(n-1)$ degrees of freedom. If

TABLE 2

MEASUREMENTS OF ADULT SANDHILL CRANES COLLECTED DURING THE BREEDING SEASON[1]

	Grus c. canadensis		*Grus c. rowani*		*Grus c. tabida*	
	Male	Female	Male	Female	Male	Female
Sample Size	36	17	10	3	11	7
Wing Chord						
Mean	469.1	445.5	503.9	472.7	541.5	538.9
Standard deviation	22.8	21.8	16.7	20.1	25.3	28.5
Extremes	418–505	420–490	480–524	456–495	502–575	503–575
Tarsus Length						
Mean	187.4	177.6	228.8	210.7	240.0	229.4
Standard deviation	12.7	11.3	7.6	5.5	9.9	5.4
Extremes	160–210	156–198	216–239	205–216	226–253	223–237
Exposed culmen						
Mean	91.4	89.7	119.4	103.0	135.2	129.3
Standard deviation	7.0	5.7	6.4	10.5	7.5	11.9
Extremes	69–102	80–101.6	109–127	93–114	122–144	113–147

[1] Linear measurements in millimeters; data from Walkinshaw (pers. comm.) and Lumsden (1971).

F_0 is not significant, it is then valid to further test the likelihood that X represents a *canadensis* member. This is tested by comparing

$$F_1 = (n-2)[(\mu_c - \mu_t)'S^{-1}(X - \mu_c)]^2/[(\mu_c - \mu_t)'S^{-1}(\mu_c - \mu_t) \times (n + 2nF_0/(n-1))]$$

to an F variate with 1 and $(n-2)$ degrees of freedom. An analogous value F_2 with μ_t replacing μ_c can be calculated to test that X belongs to the *tabida* population.

This sequence of statistical tests was applied to each of the 10 male and three female breeding specimens presumed to be *rowani*. The outcome for males is shown in Table 3; similar results were obtained for females. For no specimen was F_0 significant, even at the $P = 0.10$ level. This suggests that if the measurements are not from *canadensis* or *tabida*, they are from a population intermediate between them. This result is not intrinsically useful, but it validates further testing using F_1 and F_2. The calculated values of F_1 ranged from 11.51 to 32.63, and were all significant at the $P = 0.05$ level. It is thus highly unlikely that any of these specimens represents the *canadensis* population.

The results of testing for affinity to *tabida* were also significant, if not as conclusive. The F_2 values of eight male specimens were significant at the $P = 0.05$ level while the remaining two were nearly so. It follows then that those particular breeding specimens taken within the range of *rowani* are

TABLE 3

F VALUES FOR TESTING SEPARABILITY OF MALE BREEDING SPECIMENS PRESUMED TO BE *Grus canadensis rowani*

Specimen number	F_0	F_1	F_2
1	.37	20.43	8.91
2	.47	17.96	10.56
3	1.42	24.10	5.88
4	.90	30.15	3.71
5	1.33	11.51	15.65
6	.01	32.63	3.43
7	.22	25.28	6.26
8	.11	19.63	9.72
9	.60	14.22	13.65
10	1.70	26.10	4.76
Critical Values of F			
$P = 0.05$	3.21	4.06	4.06
$P = 0.10$	2.43	2.83	2.83

distinct from both *canadensis* and from *tabida*, although they appear somewhat closer to the latter population, at least in terms of wing chord, tarsus length, and exposed culmen measurements.

This sequence of tests provides stronger conclusions than would be obtained by merely comparing means of the populations. Finding a significant difference among means would indicate that *on the average* the presumed *rowani* group differs from the known populations. The tests above allow us to conclude that *each* of the questioned specimens differs from those taken in the ranges of typical *canadensis* and *tabida*. Such findings do not refute the possibility of a cline in morphological measurements, because the sampling (collection) of breeding specimens was not done uniformly throughout the breeding ranges and any groups intermediate between *tabida* and *rowani* or between *rowani* and *canadensis* may not be represented.

MEASUREMENTS OF ADULT MIGRANT SPECIMENS

For the purpose of making racial determinations of migrant Sandhill Cranes, certain linear measurements were found to be particularly useful. These include wing chord, tarsus length, and exposed culmen. To identify an individual migrant specimen, we compared its measurements to those taken from the series of breeding specimens that were representative of each of the three subspecies. The migrant specimen in question was assigned to a subspecies on the basis of similarity to measurements of the breeding specimens.

Table 4

Measurements of Adult Migrant Sandhill Cranes[1]

	Grus c. canadensis		*Grus c. rowani*		*Grus c. tabida*	
	Male	Female	Male	Female	Male	Female
Sample size	31	17	51	33	11	10
Wing Chord						
Mean	467.0	445.7	503.0	475.5	518.9	487.3
Standard deviation	15.5	12.0	12.9	14.3	9.4	13.8
Extremes	419–502	421–464	469–530	434–505	504–531	472–524
Tarsus Length						
Mean	187.5	179.2	230.6[2]	217.0	236.5	228.3
Standard deviation	14.4	10.8	9.5	7.6	8.3	6.3
Extremes	151–203	165–197	211–249	203–232	227–253	219–235
Exposed Culmen						
Mean	97.3[2]	92.0	119.7	114.1	131.8	120.4
Standard deviation	3.9	5.2	5.9	3.9	5.0	2.9
Extremes	91.6–105.9	83.2–99.7	99.6–130.6	107–122.5	124.4–141.1	114.9–125.3
Culmen post nares						
Mean	76.5	72.4	92.1	86.7	100.7[2]	93.5
Standard deviation	3.1	4.0	4.8	3.3	4.5	2.5
Extremes	70.3–84.0	63.7–78	74–102	82.8–94	95–107	90–98
Middle Toe						
Mean	75.4	73.4	86.4	83.3	87.2	84.5
Standard deviation	3.2	4.8	3.2	3.7	2.5	2.6
Extremes	69.3–82.2	61.5–78.8	80.6–93.5	77.2–92.7	83.3–91.0	79.4–88.5
Tail Length						
Mean	168.0	159.6	190.2	179.8	196.9	184.1
Standard deviation	6.5	6.7	7.4	6.0	4.5	6.2
Extremes	157–180	150–177	175–209	166–192	190–203	173–192
Weight						
Mean	3945.6	3459.9	4794.8[3]	4110.2[3]	4885.6	4453.7[2]
Standard deviation	299.6	250.1	385.3	251.9	370.8	427.1
Extremes	3235–4671	2866–3829	3890–5613	3676–4895	3870–5432	3645–5052

[1] Linear measurements in millimeters; weight in grams.
[2] Sample size one less than indicated.
[3] Sample size two less than indicated.

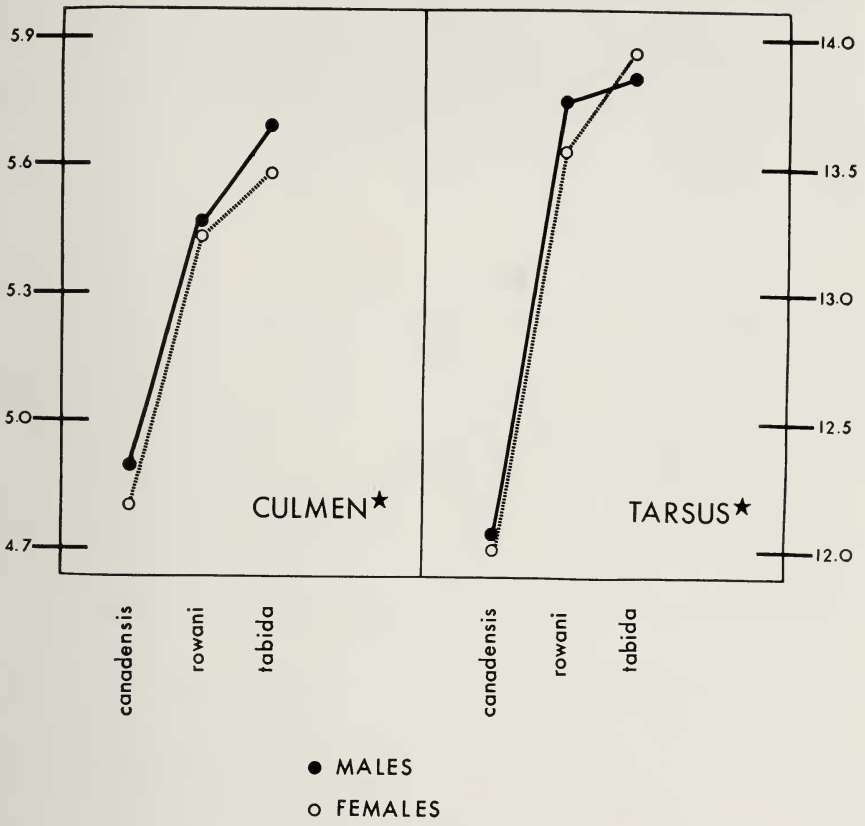

FIG. 2. Proportions of culmen post nares and tarsus measurements relative to overall body size.

Table 4 summarizes the measurements of adult migrant cranes in accordance with our racial determinations. Included are the mean, standard deviation, and extremes for wing chord, tarsus length, exposed culmen, culmen post nares, middle toe (without claw), tail length, and weight for males and females of each subspecies.

It is clear that the subspecies of *Grus canadensis* differ in body measurements; *tabida* is the largest, *canadensis* the smallest, and *rowani* intermediate. The possibility remains that the three subspecies also differ in their relative body proportions. This question was considered by investigating the ratio of linear dimensions, e.g. tarsus length, to a measure of general body size. Amadon (1943) presents a case for using the cube root of weight as a mea-

Table 5
Geographic and Seasonal Composition of Adult Migrant Sandhill Cranes

	Grus c. canadensis	*Grus c. rowani*	*Grus c. tabida*
Kittson Co., Minnesota			
22–24 September 1970	0	7	13
Pierce Co., North Dakota			
14 September 1971	0	11	1
27–28 October 1971	0	8	0
Kidder Co., North Dakota			
8–15 September 1970	0	24	1
26 October–1 November 1970	2	16	3
3–4 September 1971	0	12	3
McLean Co., North Dakota			
28 October–3 November 1970	26	1	0
7 September 1971	0	5	0
27–28 September 1971	8	0	0
Phillips Co., Montana			
4 October 1970	4	0	0
3 October 1971	8	0	0

sure of overall body size. (The value of the cube root is interpreted as being comparable to a linear dimension.)

Although weights were not available for breeding specimens (nor, indeed, was any measure of general body size), all cranes collected for the present study were weighed. So by assuming that our classification of subspecies is correct, we may proceed by examining each specimen for the quantities:

$$\text{culmen}^* = \text{culmen post nares}/(\text{weight})^{1/3}$$

and

$$\text{tarsus}^* = \text{tarsus length}/(\text{weight})^{1/3}$$

Culmen* and tarsus* represent measurements relative to body size. Averages of these quantities can then be compared among subspecies. Of the remaining measurements, we considered only the corresponding function of wing chord, which did not prove useful.

The averages of culmen* and tarsus* for male and for female specimens of each race are graphed in Figure 2. One *t*-test was employed to test the difference between *canadensis* and *rowani*, and another for the difference between *rowani* and *tabida*. All differences were significant ($P = 0.05$) except for the difference in tarsus* between male *rowani* and *tabida*.

It would be preferable if measurements from breeding Sandhill Cranes of

known origin could be used for this analysis; however, until such data become available, we may tentatively conclude that the subspecies differ not only in overall body size, but also in relative proportions. It should be noted that the *rowani* means lie closer to *tabida* than to *canadensis*, a situation analogous to one encountered earlier when testing the separability of individuals of the intermediate race. Also, the differences between *rowani* and *tabida* are more acute in culmen measurements than in tarsus length, a feature noted by Aldrich (pers. comm.).

RACIAL COMPOSITION OF MIGRANT POPULATIONS

The samples of adult migrant specimens (Table 5) exhibit considerable geographical variation in racial composition. The data from these samples indicate that three fairly distinct migrant populations are represented: a population in northwestern Minnesota that is dominated by the Greater Sandhill Crane; a population in Pierce and Kidder Counties, North Dakota, that is dominated by the intermediate Canadian Sandhill Crane; and a population in McLean County, North Dakota, and Phillips County, Montana, that is dominated by the Lesser Sandhill Crane. It is noteworthy that gross differences in racial composition exist between the migrant populations of Kidder County and those in McLean County despite a distance of less than 70 miles separating the two sites. The similarity in racial composition between the migrant populations of Kidder County and those of Pierce County, which lies about 70 miles north, suggests that these cranes may have originated from the same geographical breeding grounds. Variations in racial composition of specimens from the North Dakota collections are illustrated in Figure 3.

The Greater Sandhill Crane was found to comprise 65 percent of the late September sample from northwestern Minnesota. This relatively high proportion is of special interest since the total numbers of cranes that congregate in this area probably exceed 3000 birds. In addition, this subspecies comprised small proportions (5 to 11 percent) of the total sample specimens from the concentration areas in Kidder and Pierce Counties, North Dakota, which generally support peak fall populations of 10,000 or more birds. Apparently the present eastern population of the Greater Sandhill Crane is much larger than has been generally realized.

The Canadian Sandhill Crane comprised about 95 percent of all the sample specimens collected from Pierce County and about 85 percent of the sample specimens from Kidder County. This subspecies also is an important component of the northwestern Minnesota population since it comprised 35 percent of the sample from there.

In McLean County, North Dakota, a small population of about 250 Sandhill Cranes was present in early September 1971. The five adults collected from

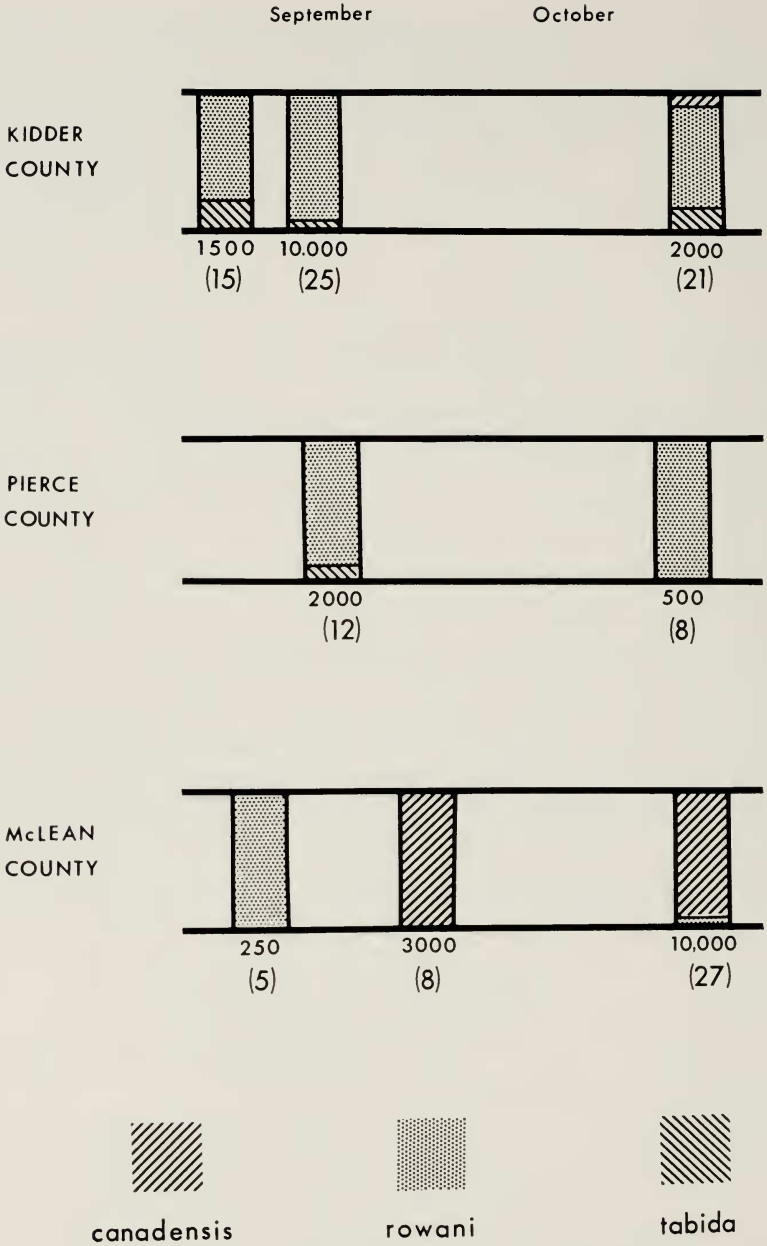

FIG. 3. Racial composition of migrant Sandhill Cranes from North Dakota, indicating seasonal variation in samples from various locations. Also shown are estimates of the population present during the collection period, and, in parentheses, the sizes of the samples.

TABLE 6

MEASUREMENTS OF IMMATURE MIGRANT SANDHILL CRANES[1]

	McLean Co., N. D. Phillips Co., Mont.		Kidder & Pierce Cos., N. D.		Kittson Co., Minn.	
	Male	Female	Male	Female	Male	Female
Sample Size	5	5	4	6	3	4
Wing Chord						
Mean	455.4	447.0	493.5	463.8	505.3	469.0
Standard deviation	9.0	16.2	9.5	9.7	8.1	26.7
Extremes	446–465	424–469	481–503	447–474	496–510	441–499
Tarsus Length						
Mean	196.8	189.2	229.5	202.5	240.7	224.5
Standard deviation	13.1	15.7	10.7	15.6	8.1	8.7
Extremes	178–212	175–215	215–240	180–226	232–248	216–232
Exposed Culmen						
Mean	85.7	85.0	109.4	98.1	115.3	103.2
Standard deviation	8.4	6.8	8.9	7.0	5.1	9.3
Extremes	73.7–95.9	77.2–95.4	96.5–116.3	86.8–105.4	111.7–121.1	89.7–109.4
Culmen post nares						
Mean	66.6	67.2	84.8	76.9	90	81.9
Standard deviation	6.2	5.0	7.5	7.3	2	8.2
Extremes	57–73	60.8–72	74–90	67.2–83	88–92	70–87.5
Middle Toe						
Mean	75.7	73.0	84.4	81.0	86.6	83.0
Standard deviation	5.6	4.1	4.4	2.9	2.8	2.3
Extremes	66.1–80.0	70.5–80.2	79.2–90.0	75.6–83.7	84.9–89.8	80.8–86.2
Tail Length						
Mean	157.0	156.0	178.2	162.0	184	170.8
Standard deviation	5.9	4.1	9.3	7.2	1	8.9
Extremes	152–167	150–161	166–188	153–171	183–185	160–179
Weight						
Mean	3475.8[2]	3157.4	4389	3715.2[3]	4310.7	3794.0
Standard deviation	428.7	287.7	738.0	505.5	295.1	535.5
Extremes	3027–4024	2880–3512	3415–5082	3270–4360	4058–4635	3022–4258

[1] Linear measurements in millimeters; weight in grams.
[2] Sample size one less than indicated.
[3] Sample size two less than indicatel.

this group were identified as the intermediate subspecies, *rowani*. Later in the season, from late September to early November, many thousands of Sandhill Cranes congregate in this area. Series of specimens that totaled 35 adults were collected from these late aggregations in 1970 and 1971. Since only one of these (3 percent) was identified as *rowani*, we hypothesize that the small numbers of this subspecies which arrive early in this staging area are subsequently greatly outnumbered when the large flocks of *canadensis* arrive.

The arrival of flocks of Lesser Sandhill Cranes on the migration staging areas is noticeably later than the arrival of the Greater and Canadian Sandhill Cranes. Ordinarily the population build-up begins in late September as compared to late August for the other two subspecies. During the period of peak numbers, the Lesser Sandhill Crane comprised about 97 percent of the sample specimens from McLean County, North Dakota, and 100 percent of the sample specimens from Phillips County, Montana. In Kidder County this subspecies represented a very small proportion (3 percent of the sample) of the population.

Buller (1967) summarized information on the racial composition of Sandhill Crane specimens that had been collected in a non-random fashion in McLean County and in the Kidder County area during the fall migration periods of previous years. A sample of five specimens collected 23–24 September 1964, in McLean County included 4 *canadensis* and 1 *rowani*. Another collection of five made one month later in the same location had an identical racial composition. The Kidder County sample of 33 specimens taken 22 September–2 November 1965, contained 29 *rowani* and four *canadensis*. Data from small samples (13 taken 27 October–3 November 1959; 12 taken 9–12 September 1960; seven taken 16–19 October 1963; four taken 8–12 September 1964; four taken 19–23 October 1964) in the Kidder County area showed that *canadensis* predominated in some of the collections made after mid-October. Additional measurements from a series of nine specimens of adult Sandhill Cranes from southeastern Wyoming (Goshen County) are also of interest since this location lies approximately 475 miles south-southeast of the staging area in Phillips County, Montana. These birds were collected by the Wyoming Game and Fish Department during 28–30 October 1971. As might be expected, all of these specimens proved to be Lesser Sandhill Cranes.

MEASUREMENT OF IMMATURE MIGRANT SPECIMENS

The collections of immature Sandhill Cranes, although largely incidental, provided some insight into the comparative size of these cranes as related to area of collection. Reliable racial determinations cannot be made for immatures because series of measurements of immature cranes of known sub-

species are lacking. For this reason we grouped immatures by geographic locations within which the racial composition of adults was similar. Table 6 gives the mean, standard deviation, and extremes of measurements for males and females from (1) Kittson County, Minnesota; (2) Kidder and Pierce Counties, North Dakota; and (3) McLean County, North Dakota and Phillips County, Montana. In general, the mean linear measurements and weights indicate that immature birds from Kittson County, Minnesota, were comparatively large; those from McLean County, North Dakota, and Phillips County, Montana, were comparatively small; whereas birds from Pierce and Kidder Counties, North Dakota, were intermediate.

NEED FOR FURTHER RESEARCH

Before appropriate management procedures can be developed for migrant populations of Sandhill Cranes, additional research concerning other important aspects of their breeding biology and distribution must be undertaken. A careful delineation of the breeding range of each of the respective subspecies should be of high priority. Information thus obtained would help to clarify the separability of the various populations. The numerical status and population dynamics of each identifiable group also need to be determined, particularly if hunting becomes an appreciable mortality factor. More detailed information concerning migration patterns and locations of wintering grounds (such as obtained by Williams and Phillips, 1972) is also required.

SUMMARY

A statistical analysis employing measurements of breeding specimens representing the three migrant subspecies of Sandhill Crane (*Grus canadensis canadensis*, *Grus c. rowani*, and *Grus c. tabida*) provided supportive evidence that the intermediate population, *rowani*, is separable on the basis of wing chord, tarsus length, and exposed culmen.

A series of 180 migrant Sandhill Cranes was collected in Minnesota, North Dakota and Montana during the fall migration periods in 1970 and 1971, and racial determinations were made according to similarity with breeding specimens of known origin. On the basis of this classification, it was demonstrated that the subspecies differ in relative proportions to body size of tarsus length and culmen post nares as well as differing in overall body size. The racial composition of migrating cranes collected in different areas varied; *tabida* was predominant in Kittson County, Minnesota; *rowani* in Kidder and Pierce Counties, North Dakota; and *canadensis* in McLean County, North Dakota and Phillips County, Montana. Measurements of immature cranes were found to vary in the same general way as those of adults.

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LITERATURE CITED

Aldrich, J. W. 1946. Speciation in the white-cheeked geese. Wilson Bull., 58:94–103.

Amadon, D. 1943. Bird weights as an aid in taxonomy. Wilson Bull., 55:164–177.

Anonymous. 1958. Rare and endangered fish and wildlife of the United States. U.S. Bureau of Sport Fisheries and Wildlife. Resource Publ. 34. Washington, D.C.

Boeker, E. L., J. W. Aldrich, and W. S. Huey. 1961. Study of experimental Sandhill Crane hunting season in New Mexico during January 1961. U.S. Bureau of Sport Fisheries and Wildlife. Special Scientific Report—Wildlife No. 63. Washington, D.C.

Buller, R. J. 1967. Sandhill Crane study in the central flyway. U.S. Bureau of Sport Fisheries and Wildlife. Special Scientific Report—Wildlife No. 113. Washington, D.C.

Hanson, H. C. 1965. The Giant Canada Goose. Southern Illinois Univ. Press. Carbondale.

Lumsden, H. G. 1971. The status of the Sandhill Crane in northern Ontario. Canadian Field-Naturalist, 85:285–293.

Madsen, C. R. 1967. Food and habitat selection by fall migrant Sandhill Cranes in Kidder County, North Dakota. Unpubl. M. S. thesis. Michigan State Univ., East Lansing.

Rao, C. R. 1962. Use of discriminant and allied functions in multivariate analysis. Sankhya, A24:149–154.

Rao, C. R. 1965. Linear statistical inference and its applications. John Wiley & Sons, Inc. New York.

Stephen, W. J. D. 1967. Bionomics of the Sandhill Crane. Canadian Wildlife Service Report Series—No. 2. Ottawa.

Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. U.S. Bureau of Sport Fisheries and Wildlife. Resource Publication 92. Washington, D.C.

Walkinshaw, L. H. 1949. The Sandhill Cranes. Cranbrook Institute of Science Bulletin No. 29. Bloomfield Hills, Michigan.

Walkinshaw, L. H. 1965. A new Sandhill Crane from central Canada. Canadian Field-Naturalist, 79:181–184.

Williams, L. E., Jr., and R. W. Phillips. 1972. North Florida Sandhill Crane populations. Auk, 89:541–548.

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